# NOTE ON THE PERMIAN SEQUENCE IN THE WERRIE BASIN.

## WITH DESCRIPTION OF NEW SPECIES OF FOSSIL PLANTS.

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(Four Text-figures.)

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### *Introduction.**

The following observations were made by the writer, chiefly in the year 1932, in the course of the structural mapping of the Werrie Basin. The main problems of the investigation were the geological structure and the Carboniferous stratigraphy. The infolded Permian rocks were examined incidentally to that work, but as they were not the prime subject of enquiry the present discussion of them is not so exhaustive as it might otherwise be.

Little work has hitherto been published concerning the Permian strata of the Werris Creek district. Carne (1913) recorded the occurrence of *Glossopteris*-bearing sandstones, which had been discovered by Mr. Hammond of Escott Park. Carne suggested that they might be correlated with the Greta horizon. These were later examined by Benson, who (1920, p. 306) tentatively referred them to the Upper Coal Measures. This suggestion has been proved to be correct by the present writer. Benson (l.c., p. 301) also described the Werrie Basalts, but regarded them as Carboniferous. He did not recognize the Lower Coal Measures, but grouped them with the tuffs and conglomerates of the Kuttung Series. Later, coal was discovered at Currabubula by Mr. Eugene McCarthy, and was briefly reported by Raggatt who, following Benson, regarded it as Carboniferous. In 1931 McCarthy discovered plant fossils which were identified as Permian by the present writer, thus also establishing the age of the Werrie Basalts.

The general distribution and structural relations of the Permian strata in the Werrie Basin have already been recorded (Carey, 1934). Reference will be made in this paper to the maps and sections accompanying that article.

The writer wishes to express his thanks to Professor W. R. Browne, for his constant advice and encouragement, and to Dr. Walkom, for helpful discussion of the plant fossils. He has also enjoyed the company and assistance of Mr. McCarthy of Currabubula on many of his fossil-collecting expeditions. The author is also grateful to Mr. H. Thomas for placing at his disposal records of the prospecting bores put down by him at Werris Creek. Many residents of the region, who have been referred to in the earlier paper, have assisted in the work by their liberal hospitality, and in connection with the Permian work one has particularly to thank Mr. and Mrs. McCarthy of Currabubula, Mr. and Mrs. Middleton of "Dunolly", Werris Creek, and Mr. and Mrs. W. R. Bridge and family of "Willawa", Quipolly Creek.

* The work on which this paper is based was done while the author was holding the Deas-Thomson Scholarship in Geology and a Science Research Scholarship of the University of Sydney.

*The Lower Coal Measures.*

The Lower Coal Measures overlie the Kuttung Series with apparent conformity, and underlie the Werrie Basalts. They are well developed along the eastern and southern side of the Werrie Basin, and around the Quipolly and Castle Mountain Domes. They wedge out rapidly in the north-west, and are overlapped by the Werrie Basalts. As the result of the overlap the series does not outcrop in the Piallaway sector. A line from the Gap to Currabubula roughly defines the limit of their extension to the north-west.

The rocks are very conglomeratic on the whole, but interbedded with the conglomerates are tuffs, sandstones, shales, and coal-seams. Nearly all the strata are somewhat tuffaceous. The facies becomes notably coarser eastwards. The thickness of the series may be up to 500 feet.

*Economic Importance.*—Evidence of the presence of coal in these beds is not lacking. Three shafts at Currabubula revealed a seam between ten and fifteen feet thick, heavily cindered by invading sills of keratophyre from the Warrigundi complex. A bore on portion 68, Parish of Werrie, a couple of chains north-west of the outcrop of the series, bottomed in coal at 80 feet; another water bore in portion 32 Werrie bottomed at a depth of 213 feet in a seam of coal alleged to be 20 feet thick. Still another bore 100 feet deep, near the boundary of the Lower Coal Measures at the northern end of the Jacob-and-Joseph Basin, also struck coal. Furthermore, in portion 20 in the Parish of Werrie, a weathered coal-seam at least 2½ feet thick outcrops in the cliff face; the unperished coal-seam is probably considerably thicker. This seam is intruded by a sill. In portions 136 and 205 in the Parish of Quirindi, in a tributary gully to Rocky Gully, weathered coal-seams and carbonaceous shales outcrop at the surface. Similar exposures are found in portion 185, Quirindi.

Thus there can be no doubt concerning the existence of coal-seams in the series. The quality of the coal can at present only be inferred from our knowledge of the same series elsewhere. The possible influence of the Warrigundi intrusives is, however, important. It is evident that in the northern part of the area what coal there is is destroyed by these intrusions. However, in the preliminary discussion of the Warrigundi rocks (Carey, 1934) it has been shown that the sills and dykes have a definite range beyond which they rarely, if ever, go. These ranges are seven and six miles respectively measured from the Warrigundi centre. The hybrid sheets extend southwards for much greater distances, but they are always confined to the Werrie Basalts, and so are quite innocuous. Thus beyond a zone of about seven miles from Warrigundi centre there need be little fear of trouble from this source. Occasional members of the older dyke series may be met, but these are never very abundant. The Jacob-and-Joseph Basin, the southern nose of Quipolly Dome, and the basin at the southern limit of the area mapped may be considered free from extensive igneous invasion. Parts of Quipolly Dome show much minor dislocation, and the Quirindi Dome is closely followed by the overthrusts, so the most promising area for commercial operations is the extensive Jacob-and-Joseph Basin, which shows no disadvantages in the way of volcanic intrusions or faults, and is easy of access.

*Fossil Flora.*—The discovery of the *Gangamopteris-Noeggerathiopsis* flora in this district, by Mr. McCarthy, has resulted in a considerable extension of our known Lower Coal Measures, and has led to the dating of the Warrigundi vulcanism and the Werrie Basalt extrusions. The fossils have been found by the present writer at many localities along the outcrop of the series. The following types have been

collected: *Noeggerathiopsis Hislopi*, *Gangamopteris cyclopteroides*, *Gangamopteris* sp. α (? n. sp.), *Gangamopteris* sp. β, *Glossopteris* cf. *Browniana*, *Palaeovittaria McCarthyi*, n. sp., *Neocalamites* (?), *Cornucarpus striatus*, n. sp., *Cordaicarpus emarginatus*, n. sp.

The seeds collected by the writer have been described by Walkom (1935). The description of the silicified wood given below is the work of Mr. R. N. Robertson, B.Sc., Science Research Scholar in Botany in the University of Sydney.

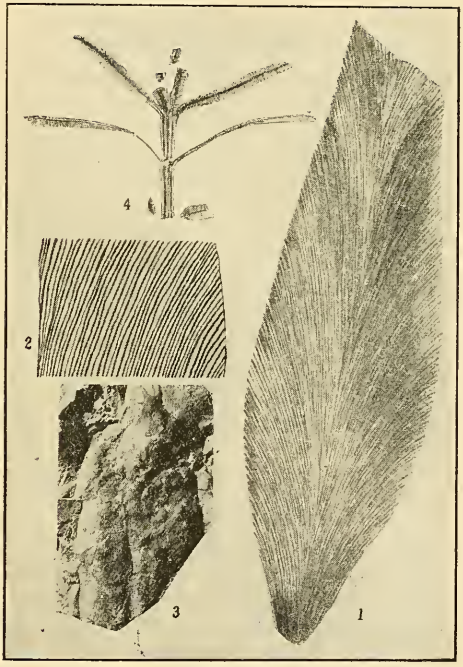
## Genus Palaeovittaria.

### Palaeovittaria McCarthyi, n. sp. Text-figs. 1–2.

Type, Specimen W263, Museum of Geology, University of Sydney.

Frond oval-lanceolate, length about 15 cm. when complete, breadth 3·8 cm. at widest part, which is almost one-third of the distance from the base to the apex; apex not preserved. Venation non-reticulate, erect, slightly arching and spreading at a narrow angle, occasionally dichotomizing. There are about twenty veins to the centimetre.

This leaf is very similar in size and shape and in the general character of the venation to *Palaeovittaria Kurzi* Feistmantel (1876, p. 368; 1880, p. 91), which occurs sparingly in the Raniganj group of the Damuda division in India and the Triassic beds of Tonquin. It differs from that species in the absence of the median fold, the more arched venation, and the very much closer spacing of




Text-figs. 1-4.

1, 2.—*Palaeovittaria McCarthyi*, n. sp. Fig. 1, × $\frac{2}{3}$; Fig. 2, venation, × $\frac{4}{3}$.

3.—*Gangamopteris* sp. α. × $\frac{2}{5}$.

4.—*Neocalamites striatifolia*, n. sp. × $\frac{4}{3}$.

the veins. In view of these differences, together with its rather lower horizon, it seems wise to refer it to a new species. I have much pleasure in dedicating it to Mr. McCarthy of Currabubula.

Noeggerathiopsis Hislopi.

W158, W347*b*. This species is very abundant on some horizons as sub-linear leaves widening gradually from the base. The longest specimen is 18 cm., incomplete.

Gangamopteris sp. α. Text-fig. 3.

W261, W268. Frond oblong, symmetrical, 10 cm. in length, 4 cm. wide, apex obtusely rounded. No midrib, but a median fold is visible for two-thirds of the length of the leaf; venation apparently reticulate, arched so that it meets the margin at an angle of 70°. The anastomosis of the secondary veins appears to be very subordinate, but it is not well shown in any of the specimens. The leaf is particularly coriaceous, being very wrinkled in two specimens, and rolled up into a cylinder in the third. I suspect that this type is a new species.

Gangamopteris sp. β.

W262 (one nearly complete frond and four fragments), W156. Frond obovate, asymmetrical, 8 cm. long, 3·5 cm. wide at the widest part, apex rounded, slight median fold, but no midrib. Veins dichotomize frequently at fairly regular intervals, and anastomose occasionally. These fronds are similar to *Gangamopteris cyclopteroides*, but I am not certain that they are referable to that species.

Gangamopteris cyclopteroides.

Several small fragments of large fronds, with the nervation well preserved.

Cordaitean Wood.

This wood is represented by two specimens. Sections of one of the specimens were made. Neither pith nor protoxylem could be found, the specimen consisting of secondary xylem. Though the specimen seems to have been considerably crushed, resulting in convolutions in the wood, there is definite evidence of annual rings. This crushing has also destroyed the shape of the xylem elements in transverse section. The longitudinal section shows the xylem to consist of tracheids, which, though not well preserved, show pits on their radial walls. The pits are the characteristic bordered pits of the Cordaitales. Both transverse and longitudinal sections show numerous medullary rays. In transverse section they are one cell in width. Longitudinal section shows them to be several cells high. The rays are composed of parenchymatous cells which appear rectangular in section.

*Correlation.*—Some doubt arises as to whether the Lower Coal Measures of the Werrie Basin are on the Greta Horizon, or whether they correspond to a horizon in the Lower Marine Series, as do some of the coals of Queensland. This doubt is at first sight aggravated by the fact that the Werrie Basalts are similar to the well developed melaphyres of the Lower Marine Series. However, although alkalized basalts have been regarded as typical of the Lower Marine, evidence of their development in Upper Marine strata is not lacking. Browne (1929, p. xxix) points out: "Evidence has been found to the east of Raymond Terrace suggesting strongly that these basaltic eruptions were continued into Greta Coal Measure times, and at Jerry's Plains Mr. H. G. Raggatt has discovered, interbedded with the Upper Coal Measures, amygdaloidal basalts with analcite-lined

vesicles . . . at Temi, near Murrurundi, analcite-bearing basic lavas are interbedded with strata at least as young as Upper Marine."

Unfortunately no marine fossils have yet been found in the Werris Creek–Currabubula area which might settle this question of the age of the Werrie Basalts. In their absence the exact horizon will probably not be established until the area is linked with the Hunter Valley by continuous mapping.

Our knowledge of the time-distribution of the Permian floras is not sufficiently complete to give precise correlation based on them alone. The flora of the Lower Coal Measures of the Werrie Basin contains many elements which are different from the Greta flora of the Hunter Valley. *Glossopteris* is less abundant, and most of the *Gangamopteris* belongs to species with much less reticulate venation. This tendency is carried to the limit in *Palaeovittaria*. *Noeggerathiopsis* is more abundant, in this respect recalling the flora of the Ashford beds (Pittman, 1896, p. 21). Indeed the flora in the Werrie Basin is in many ways intermediate between those of Ashford and Greta. The assemblage is much more in keeping with the Greta than the Upper Coal Measures, but it is impossible to state from the flora alone whether it is of Greta or Lower Marine age.

Lithologically the Werrie Basin Coal Measures are undoubtedly very similar to the Greta Series elsewhere. The association of conglomerates, grits, and characteristic tuffs with thick coal-seams is very typical.

The areal distribution of the Lower Permian units provides another line of evidence. For, as the Permian strata are traced north-westwards from Scone to Wingen, the Lower Marine beds beneath the Greta Coal Measures gradually thin out, so to find that, some thirty miles further to the north-north-west, the coal measures rest directly on the Kuttung is not unexpected. Furthermore, at Temi, which occupies an intermediate position, there are some basalts both above and below the coal, the presumption being that the lower basalts represent the Lower Marine Series. Still further to the north-north-west the coal measures are also overlapped, and the basalts rest directly on the Carboniferous rocks, which have in turn also thinned.

But, although these units wedge out in the north-north-west, it does not follow that they also decline to the north and north-east. Indeed, at Nundle Permian marine fossils, which are quite absent at Werris Creek and Currabubula, have been recorded by Stonier (1891, p. 261) and Benson (1913, p. 586), and the extensive development of Permian marine beds further north is well known.

Thus, reviewing all the available data concerning flora, lithology, and areal distribution, I consider that there is strong evidence for regarding the Lower Coal Measures of the Werrie Basin as being strictly comparable with the Greta horizon, but until the correlation is established by the systematic mapping of the intervening region, the case cannot be regarded as proved.

### *The Werrie Basalts.*

The Werrie Basalts are a series of alkalized basic lavas, about five thousand feet in thickness. The series is very extensive, covering more than 100 square miles within the trough of the Werrie Basin between Piallaway and Castle Mountain. They also occur immediately to the west of the range of Kuttung rocks which lies to the west of Werris Creek, and it seems probable that much of the black soil-covered lowlands of the Breeza Plains is due to the erosion *in situ* of this formation, and not to the presence of Burindi rocks under alluvial black soil cover as was suggested by Benson (1921, pp. 299–300). Indeed the

occurrence near Boggabri of basic amygdaloidal lavas similar in appearance to the Werrie Basalts would suggest a far greater extension of this formation than has hitherto been recognized. Southwards these rocks extend towards Temi, but beyond the range they have not been traced.

Stratigraphically the Werrie Basalts occupy the hiatus between the *Gangamopteris-Noeggerathiopsis* beds and the Upper Coal Measures with *Glossopteris*, so that their age is fixed between limits corresponding approximately to the Upper Marine Series of the Hunter Valley. The junction with the underlying beds is quite conformable; indeed, one often finds thin beds of fossiliferous sandstone and shale interstratified with the lower flows. Good exposures of the relationship between the two series may be seen in portions 133 and 134 in the Parish of Werrie. In portion 161 in the Parish of Quipolly, near Mr. Chapman's homestead, the interstratified shales contain a cindered and brecciated coal-seam. At the same locality the sediment appears to have been a soft mud, and the basalt settled into it in the form of blocks and chilled fragments, giving interesting contact-effects. The sandstone in contact with the lavas often shows well-developed prismatization. Such interbedding of thin layers of sandstone between the lower flows is rather common in the Fairfield Basin, along the eastern side of the Jacob-and-Joseph Basin, and in the succeeding basin to the south, but never appears further west, thus suggesting that the sedimentation came from the east, a view supported by the increasing coarseness of the sediments in that direction. Since the interbedded sandstones often contain plant fossils such as *Gangamopteris*, *Noeggerathiopsis* and *Glossopteris*, it is evident that the extrusions commenced in Lower Coal Measure times.

The sequence at the top of the series is again conformable, but it is not certain how much time elapsed between the last extrusions and the initiation of the Upper Coal Measure sedimentation. The highest beds are clastic, but it is difficult to say whether they are tuffs, or material derived from the contemporaneous erosion of the lavas. They are of medium to fine grainsize, without a marked stratification, and have a rich chocolate colour.

It would be unwise, therefore, to state that the Werrie Basalts were extruded throughout the time-interval of the Upper Marine Series. The most definite conclusion which can be made on the present evidence is that they occupy the stratigraphical interval of the Upper Marine Series, together with the Tomago Coal Measures and the Dempsey Series, and that they commenced in Lower Coal Measure time, but the last flow may have been extruded a considerable time before the beginning of the Upper Coal Measure sedimentation.

The intimate association of the lower flows with the freshwater sediments, and certain constant petrological and lithological characters, suggest that the whole series was poured out under sub-aqueous, probably freshwater conditions. This implies concurrent subsidence to the extent of five thousand feet.

Typically the Werrie basalts are highly amygdaloidal, with or without evidence of flow. The abundance and size of the amygdales may change suddenly; occasionally the flows have a suggestion of crude pillow-structure, and elsewhere become slaggy and ropy. A good exposure is to be seen beneath the bridge over Jacob-and-Joseph Creek, on the east side of the town of Quirindi. The vesicle-fillings are commonly stilbite, but calcite, chlorite, analcite and other zeolites, or one or more forms of silica, also occur. Fine-grained types are found with the amygdaloidal lavas.

The series is very susceptible to weathering and erosion, and invariably forms low-lying country with heavy black soil. Exposures are rare and fresh specimens are impossible to obtain. The evidence of water bores indicates that the same decomposed condition persists, even at depths of two and three hundred feet, and it probably continues throughout.

In view of the altered state of the rocks, petrographic work is attended with considerable difficulty. Although several specimens have been sectioned, only one is from an outcrop which was not intimately associated with the Warrigundi intrusives. This was collected on the side of an unusual knoll in the centre of the Fairfield Basin. The section described by Professor Browne (1920) was of a specimen collected from a well near the head of Anstey's Creek, and was in very close contact with the Warrigundi intrusives. There can be little doubt that the specimens examined under the microscope are far from typical of the series as a whole, for it is quite the exceptional lava which makes any outcrop at all.

However, from an examination of the slides, it is evident that the Werrie lavas are uniformly basaltic, usually without olivine, although that mineral may occur. They probably carry a very high proportion of iron. They show heavy deuteric modification with an abundance of analcite, chlorite, iddingsite and other kindred minerals. The important question arises as to whether we are to consider this alteration a magmatic birth-mark dating back to the Permian or purely an accomplishment of groundwater? That the basalts are saturated with circulating groundwater there can be no doubt, for the series forms the aquifer for a fruitful sub-artesian basin. On the other hand, it needs little extension of the observed evidence in even the freshest members of the series to account for the whole of the effects as deuteric phenomena. Yet it is unlikely that the copious meteoric waters, with which the Werrie Basalts are saturated, have not superimposed their stamp on the changes already wrought by the magmatic fluids. Indeed it is probable that it is the fact that the structure favours wholesale attack by groundwaters, coupled with the initial alteration of the lavas, that has been responsible for the complete physiographic failure of these rocks.

The Werrie basalts have a good deal in common with the spilites. The main distinction is perhaps one of degree rather than of any inherent difference. It is true that the development of albite is not universal among the specimens examined, but it must be remembered that most of the material comes from the zone of influence of the Warrigundi intrusives, which were injected at a high temperature and could have regenerated the basic felspar. Such spilitic affinities could advantageously be approached with the aid of chemical analyses, but none of the Werrie Basalts has yet been analysed.

### *The Upper Coal Measures.*

The most interesting outcrop of this series is a small basin-outlier to the west of the railway line, three miles south of Werris Creek, where one of the coal-seams has been worked for a number of years. The beds have the typical lithology of the Newcastle Coal Measures, and in view of their flora and stratigraphical position there is no doubt that they are to be correlated with that series. They consist of 400 feet of conglomerates, sandstones and shales, with four coal-seams. They lie conformably on the Werrie Basalts, with which they are folded, and the view taken by Benson that the outlier is an infaulted block (1920, p. 306) has already been refuted (Carey, 1934). The folding is somewhat asymmetrical, the eastern limb being the steeper by a few degrees.

The series consists largely of sandstones, with some shales and coal-seams and some thick conglomerates at the top of the section. The conglomerates are well graded, the pebbles being almost exclusively derived from a fine white quartzite, and when screened are used for road gravel.

The thickness of the series which has been left by erosion is about 400 feet. A detailed section of the lower half of this has been provided by Mr. H. Thomas, who sank four prospecting bores on the site where the Werris Creek Colliery now stands. The details of the bores are:

| Feet. | Inches. | | |
|---|---|---|---|
| 34 | 6 | .. .. | Sandstone. |
| 11 | 0 | .. .. | White Shale. |
| 5 | 11 | .. .. | Conglomerate. |
| 2 | 2 | .. .. | Coal. |
| | 5 | .. .. | Dark Band. } No. 1 Seam (worked). |
| 8 | 10 | .. .. | Coal. |
| 54 | 11 | .. .. | Hard Sandstone. |
| 2 | 0 | .. .. | Grey Shale. |
| 3 | 0 | .. .. | Coal. No. 2 Seam. |
| 16 | 9 | .. .. | Soft Yellow Sandstone. |
| 40 | 0 | .. .. | Brown Clay Shale. |
| 5 | 0 | .. .. | Coal. No. 3 Seam. |
| 7 | 0 | .. .. | Grey Shale with *Glossopteris*. |
| 9 | 6 | .. .. | Sandstone. |
| 9 | 0 | .. .. | Grey Shale. |
| 4 | 8 | .. .. | Coal. No. 4 Seam. |
| | | | Werrie Basalts. |
| 214 | 8 | | |

Fragments of silicified Cordaitean wood are abundant in the conglomerates, and the sandstones frequently contain large impressions of plant stems, particularly in the gritty phase at the base of the series. These are sometimes quite large, one being nearly four feet long and nine inches across. An interesting flora is preserved in the shales. One horizon of pink and terra cotta shales, which outcrops on the north-east side of the outlier, gives very perfect preservation, and some new species are recorded from them. The following plants are present: *Glossopteris Browniana, Glossopteris indica, Glossopteris ampla, Noeggerathiopsis Hislopi, Phyllotheca australis, Phyllotheca* (cf.) *Etheridgei, Neocalamites striatifolia*, n. sp., ? *Pityolepis* sp., *Samaropsis moravica, Carpolithus circularis*, n. sp.

The specimens are lodged in the Museum of Geology, University of Sydney. In the following descriptions that of the Cordaitean wood is the work of Mr. R. N. Robertson, B.Sc. The fructifications collected by the writer have been described by Dr. A. B. Walkom (1935).

The *Glossopteris* fronds present a great deal of variation, but all the specimens can be referred to the three species listed, which are used in the wider sense, as defined by Arber (1905), and followed by Seward (1910), as distinct from the more restricted definitions of Feistmantel.

### Neocalamites striatifolia, n. sp. Text-fig. 4.

Type in University of Sydney, Macleay Museum. Three specimens have been collected. The nodes are up to 1 cm. apart, and the leaves are about 2 cm. long, and the thickness of the stem is about 2 mm. The surface of the stem shows parallel ribs about 0·5 mm. apart, which are continuous at the node. The leaves

are quite separate from each other throughout their entire length, and do not form a sheath. Each whorl contains about eight leaves, which are 2 cm. long and 1 mm. wide, linear, and tapering to a point. They have a distinct midrib, which seems to be composed of a bundle of parallel fibres. At right angles to the midrib are closely-set transverse striae, which often bifurcate near the margin, much like the venation of *Taeniopteris*.

W785, portion of stem showing five nodes with leaves attached; W786 shows the leaves and stem very well; W787 shows the crown of the plant with a cluster of about eight leaves.

There seems to me no doubt that these specimens must be referred to Halle's genus *Neocalamites*. They are, however, the first to be recorded from the Palaeozoic. They bear considerable resemblance to *N. hoerensis* (Schimper), but differ from it in possessing much shorter leaves, whose width is not much less than that of the stem. Their horizon, too, is much lower.

### Phyllotheca cf. Etheridgei (Arber).

About twelve specimens of unattached peltate leaves have been referred to this species. Each leaf opens out, trumpet-like, and curls slightly downward at the margin. They are usually elliptical in shape owing to the distortion, and their diameter is roughly one centimetre. The surface is finely striated with radial markings which diverge from the centre to form a finely crenulated margin. The veins are undivided and approximate to forty on each sheath. The stem is about two mm. in diameter.

These specimens differ from the *Phyllotheca Etheridgei* type-specimen in the smaller size and the apparent absence of marginal free teeth. However, if the Werris Creek specimens are not specifically identical with Arber's species, they are very closely allied.

### Cordaitean Wood.

Two specimens were obtained. Longitudinal and transverse sections were made. In transverse section the pith and primary xylem were obvious. The pith is probably about 5 mm. in diameter, but it has been crushed and it is difficult to determine its original shape. The cells of the pith are parenchymatous, mostly containing a brown substance. Occasionally there are larger cells which are devoid of contents. The primary xylem occurs in a number of bundles round the pith. The protoxylem is not well preserved but is definitely centripetal. Unfortunately the protoxylem does not appear in longitudinal section. Most of the specimen consists of secondary xylem showing annual rings. The tracheids of the secondary xylem are arranged in quite regular radial rows with numerous medullary rays. In transverse section the medullary rays are only one cell wide, but the longitudinal section shows they may be many cells high. The pitting of the tracheids is poorly preserved, but some show multiseriate bordered pits, hexagonal in shape. In some an oval pore is visible. The cells of the medullary rays appear rectangular in both radial-longitudinal and transverse sections. The cortex is apparently not preserved.

### *References.*

Arber, E. A. N., 1905.—Cat. Gloss. Flora, Brit. Mus., 1905.

Benson, W. N., 1913.—The Geology and Petrology of the Great Serpentine Belt of N.S.W. Part ii. Proc. Linn. Soc. N.S.W., xxxviii, 1913.

———, 1920.—Id., Part ix. The Geology of the Currabubula District. Ibid., xlv, 2, 1920, p. 285.

Browne, W. R., 1920.—The Geology of the Currabubula District, Section C. Ibid., xlv, 2, 1920.
————, 1929.—Presidential Address. Proc. Linn. Soc. N.S.W., liv.
Carey, S. W., 1934.—The Geological Structure of the Werrie Basin. Proc. Linn. Soc. N.S.W., lix, pt. 4, 1934.
Carne, J. E., 1913.—*Ann. Rept. Dept. Mines N.S.W.*, 1913, p. 179.
Feistmantel, O., 1876.—*Journ. Asiat. Soc. Bengal*, xiv (2).
————, 1880.—Fossil Fl. Gondw. Syst., iii (2).
Pittman, E. F., 1885.—Report on a Coal Seam near Ashford. *Ann. Rept. Dept. Mines N.S.W.*, 1885, p. 139.
Seward, A. C., 1910.—Fossil Plants, Vol. II. *Camb. Univ. Press*. 1910.
Stonier, G. A., 1891.—*Ann. Rept. Dept. Mines N.S.W.*, 1891, p. 261.
Walkom, A. B., 1935.—Proc. Linn. Soc. N.S.W., lx, p. 459.